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Enhanced Ultraviolet Output from Double-Pulsed Flash Lamps*

by

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A new method of obtaining high peak light intensity from commercial xenon flashlamps was reported recently by one of us.[1] Measurements of the spectral output as a function of current density reported here show that the enhancement is particularly great in the ultraviolet portion of the spectrum.

Very high peak light output requires a current density in the xenon above that which can usually be obtained. If the high voltage necessary to obtain a high current density is placed across the flashlamp prior to the triggering in the usual manner, when the flashtube is triggered a stable arc over the whole cross section of the tube evidently does not form. The shock wave in the plasma generated in such operation usually destroys the quartz envelope of the lamp. It has been found, however, that high current densities can be obtained if a stable low current discharge is first obtained. The flashtubes used in this work were commercial xenon flashtubes with a 7 mm inside diameter and a 75 mm length between electrodes. The flashtube is initially operated in the usual manner from a 200 μfd capacitor at 1000 volts. A 150 μhy inductor in series with the capacitor serves to limit the rate of rise of current, thereby aiding the formation of a stable discharge. Approximately 225 μ sec after triggering the flashlamp, a peak current density of 2000 amp/cm^2 is reached. At this time a 14 μf capacitor at 5500 volts is discharged, by a triggered gap, directly across the operating flashlamp. This portion of the circuit is very low impedance to allow high current and high rate of rise of current during the discharge. A minimum delay of 75 μ sec after initiation of the low current discharge is required to avoid destruction of the tube by the high current pulse.

In this manner current densities of 25,000 amps/cm^2 for several microseconds are obtained. Figure 1 shows the current through the flashtube during this type of operation.

Figure 2 shows the spectral output of the flashtube for two different current densities. A Bausch and Lomb half meter monochrometer with a 30,000 line grating set for a 35 Å wide output and an ITT FW 128 phototube were used to make these graphs. The curves are corrected for the response of the photocell but not for the blaze of the grating. As can be readily seen, the peak intensity is greatly enhanced at high current densities. At 3000 Å a factor of 100 is obtained in peak intensity. Measurement below 3000 Å have been made with a filter which monitored the 2500 Å - 3000 Å band. With this filter the ratio of peak intensities is a factor of 250 which indicates enhancement at wavelengths below 3000 Å. A photograph of the spectrum in this region is shown in Fig. 3. This is the toal integrated output of the flashlamp. The large increase in continuum intensity should be noted. Also of interest, is the extreme broadening and self absorption reversal of some of the xenon lines. In addition to the Xe I lines many Xe II lines are easily seen. The presence of discrete lines shows that the discharge is not a black body radiator, and indicates that still greater intensities might be obtained from thicker discharge tubes. Figure 4 is plot of peak intensity as a function of current density for various wavelengths. It can be seen that above 5000 Å there is little improvement above 20,000 amps/cm^2. However, at the shorter wavelengths the peak intensity increases rapidly with current density. The decay time of the light pulse falls from 8 μ sec at 6000 Å to 4 μ sec (same as current pulse) at 3000 Å indicating that at shorter wavelengths emission is primarily Bremsstrahlung rather than recombination radiation. Figure 5 shows the ratio of integrated (in time) light output of double pulse to a single long pulse of equal total energy as a function of wavelength. The efficiency of the double pulse technique at the shorter wavelength can be easily seen.

Several applications of this technique immediately present themselves. The most obvious is the pumping of materials with ultraviolet absorption bands, such as terbium, europium and gadolinium ions. This technique would also be quite valuable for pumping materials in which the fluorescent lifetime is quite short. Another interesting application is to the giant pulse operation of ruby lasers. At high levels of inversion the fluorescent lifetime is considerably reduced. This occurs because spontaneous emission from the interior of the crystal is amplified by stimulated emission as it escapes. If a large increase in intensity for a short time could be obtained just before the Q of the optical cavity is switched to a high value, a considerable improvement in the energy of the giant pulse would be obtained.

References

[1]J. L. Emmett and R. W. Hellwarth, Bull. Am. Phys. Soc. Series II, 7, 615 (1962).

Acknowledgements

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Figure Captions

Fig. 1. Current through flashlamp showing both low initial current and high current pulse.

Fig. 2. Spectral output of xenon flashlamp peak intensity.

Fig. 3. Spectrum of xenon flashlamp. Upper trace 500 μfd at 1000 volts. Lower trace 200 μfd at 1000 volts and 5500 volts at 14.0 μfd.

Fig. 4. Peak intensity as a function of current density for various wavelengths.

Fig. 5. Ratio of total output of double pulse to single pulse of equal energy.

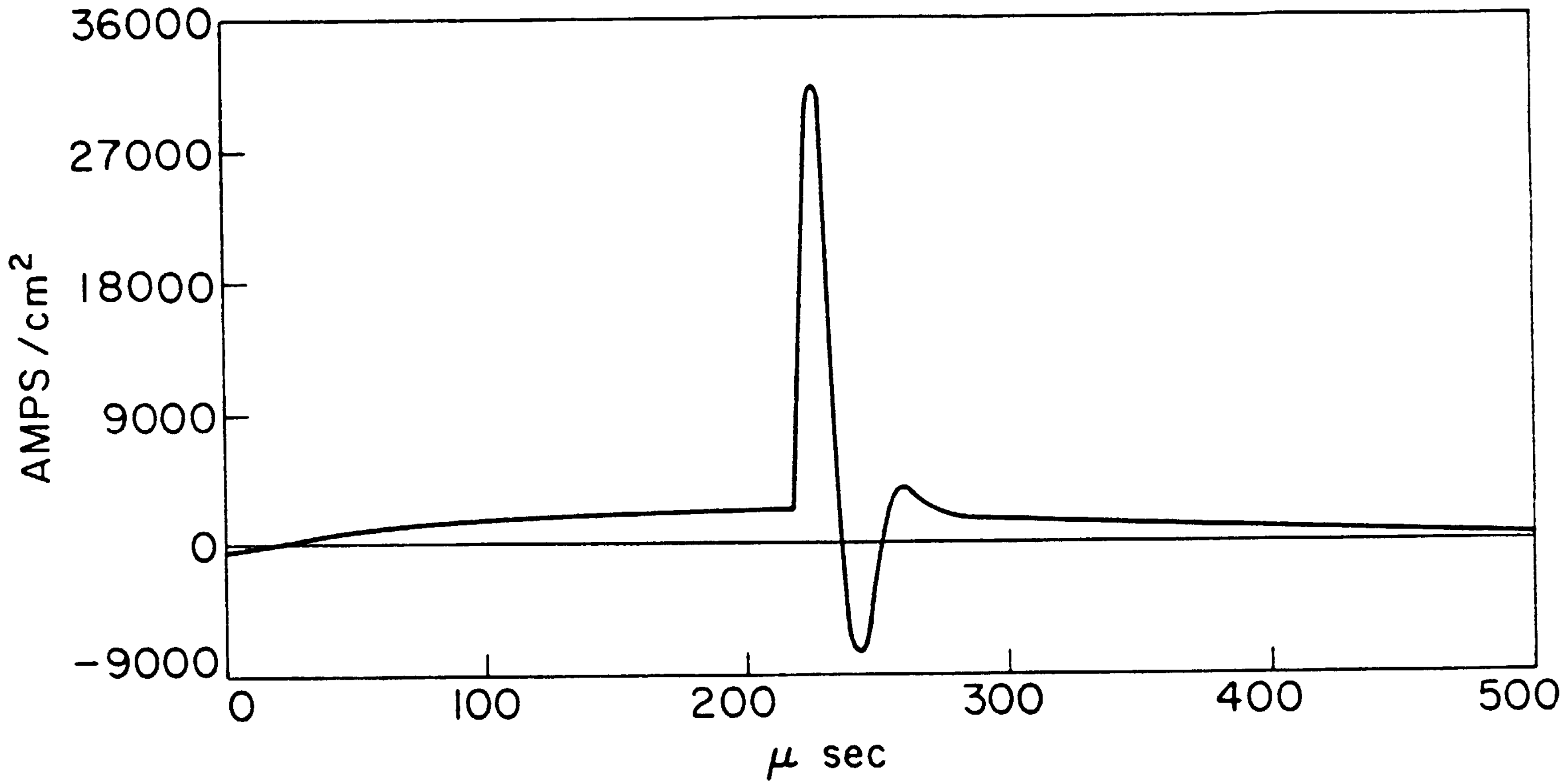
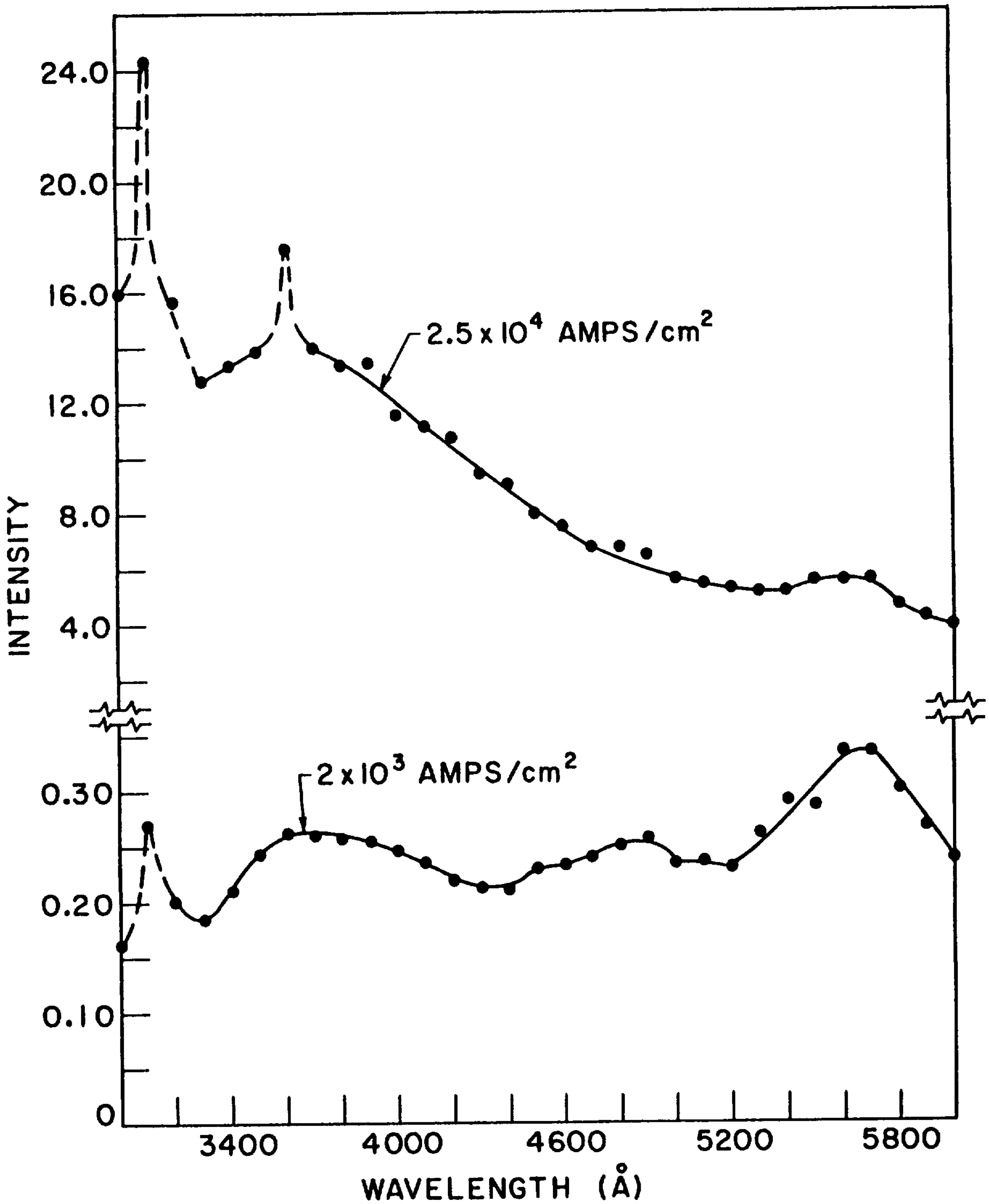

36000
27000
18000
9000
0
-9000
AMPS /cm²
0
100
200
300
400
500
μ sec

Figure 1

8



24.0
20.0
16.0
12.0
8.0
4.0
INTENSITY
2.5 x 10⁴ AMPS/cm²
2 x 10³ AMPS/cm²
0.30
0.20
0.10
0
3400
4000
4600
5200
5800
WAVELENGTH (Å)

Figure 2

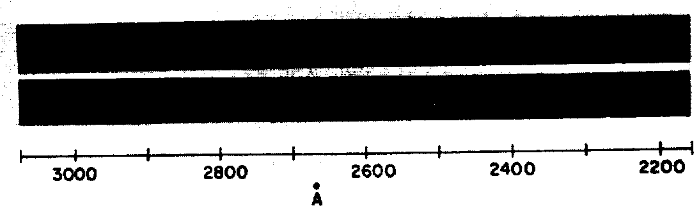


Figure 3

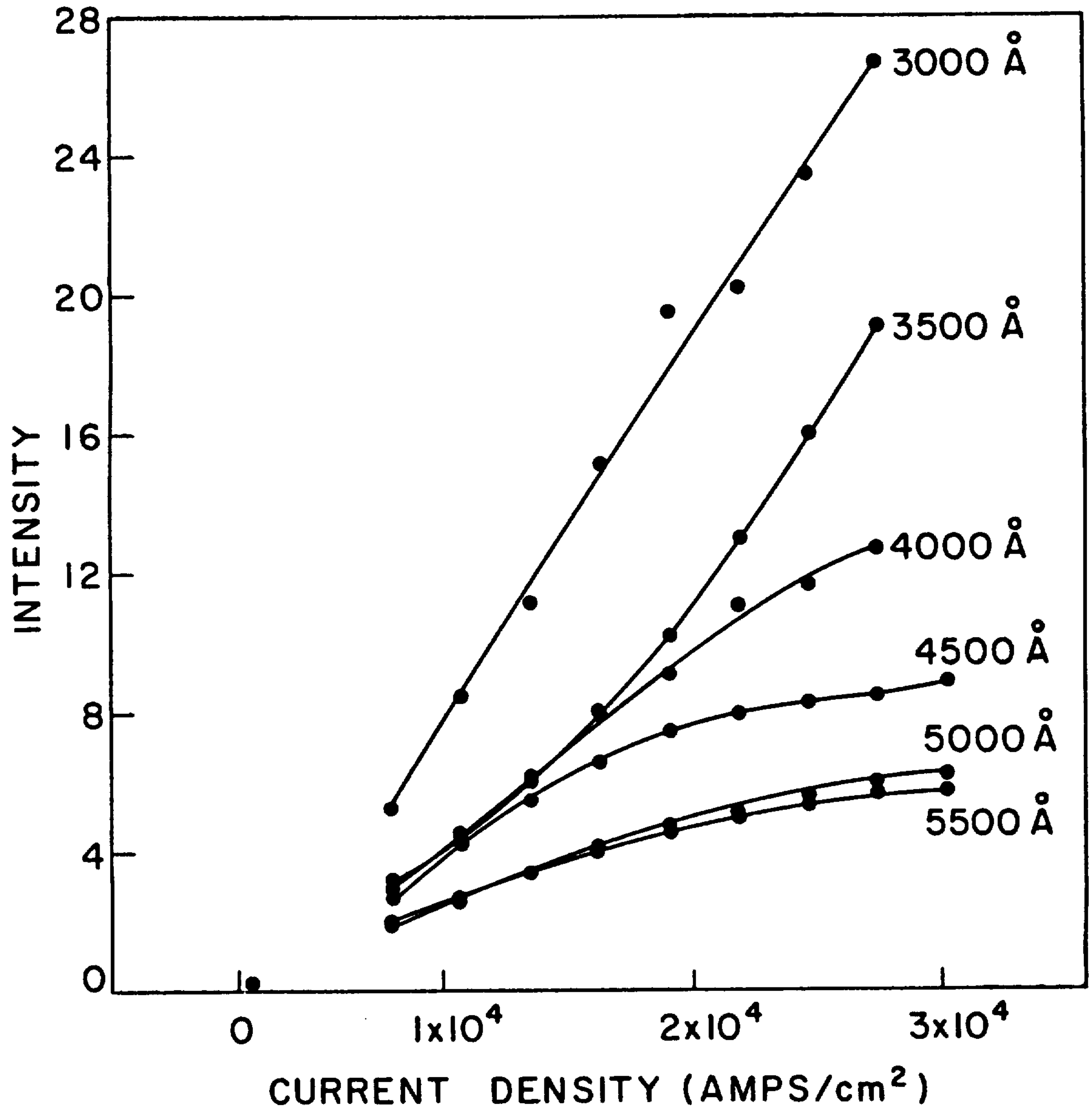

28
24
20
16
12
8
4
0
INTENSITY
0
1x10⁴
2x10⁴
3x10⁴
CURRENT DENSITY (AMPS/cm²)
3000 Å
3500 Å
4000 Å
4500 Å
5000 Å
5500 Å

Figure 4

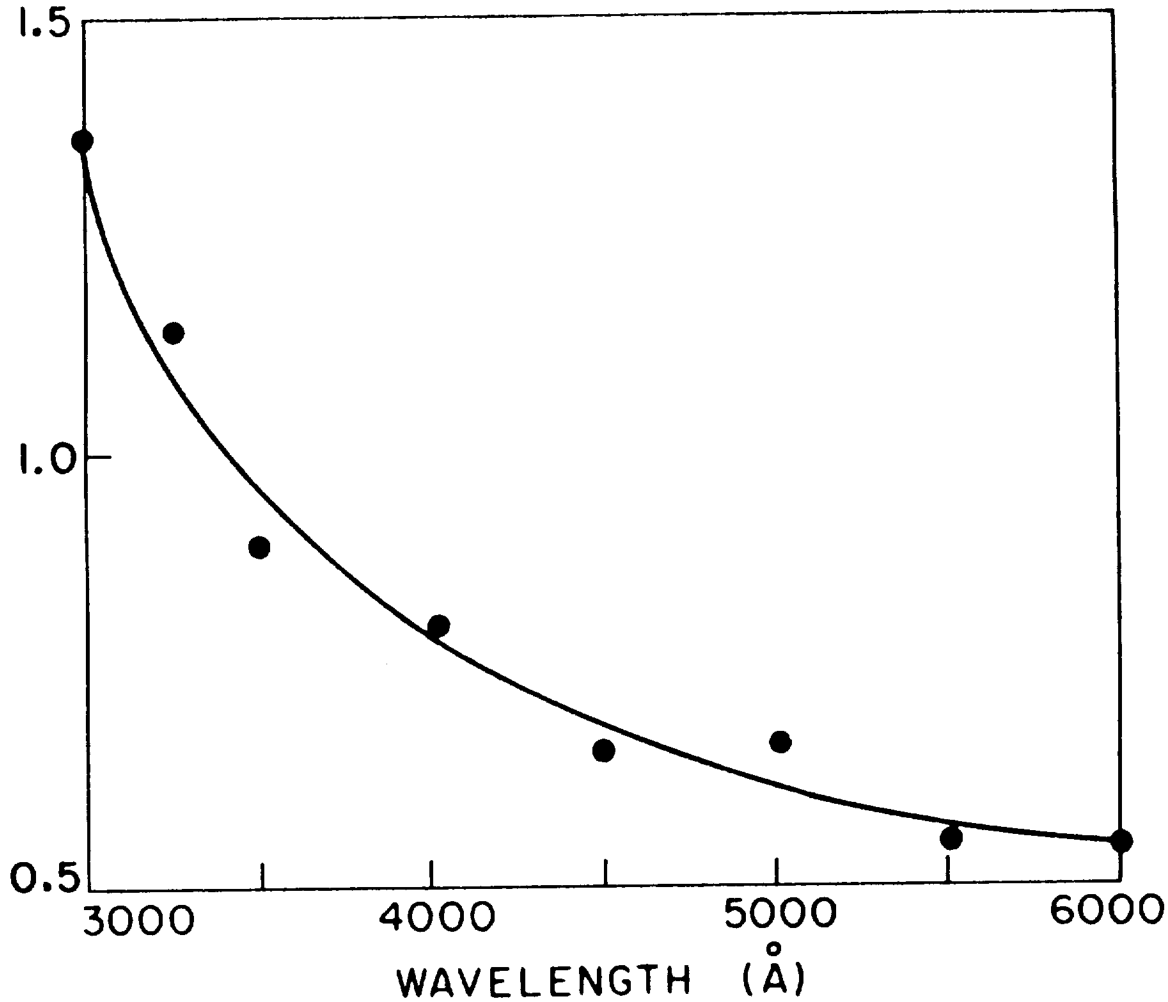


Figure 5